

## Quadratic Programming for Allocating Control Effort

A computer program calculates an optimal allocation of control effort in a system that includes redundant control actuators. The program implements an iterative (but otherwise single-stage) algorithm of the quadratic-programming type. In general, in the quadratic-programming problem, one seeks the values of a set of variables that minimize a quadratic cost function, subject to a set of linear equality and inequality constraints. In this program, the cost function combines control effort (typically quantified in terms of energy or fuel consumed) and control residuals (differences between commanded and sensed values of variables to be controlled). In comparison with prior control-allocation software, this program offers approximately equal accuracy but much greater computational efficiency. In addition, this program offers flexibility, robustness to actuation failures, and a capability for selective enforcement of control requirements. The computational efficiency of this program makes it suitable for such complex, real-time applications as controlling redundant aircraft actuators or redundant spacecraft thrusters. The program is written in the C language for execution in a UNIX operating system.

*This program was written by Gurkirpal Singh of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

*This software used in this innovation is available for commercial licensing. Please contact Karina Edmonds of the California Institute of Technology at (818) 393-2827. Refer to NPO-40592.*

## Range Process Simulation Tool

Range Process Simulation Tool (RPST) is a computer program that assists managers in rapidly predicting and quantitatively assessing the operational effects of proposed technological additions to, and/or upgrades of, complex facilities and engineering systems such as the Eastern Test Range. Originally designed for application to space transportation systems, RPST is also suitable for assessing effects of proposed changes in industrial facilities and large organizations. RPST follows a model-based ap-

proach that includes finite-capacity schedule analysis and discrete-event process simulation. A component-based, scalable, open architecture makes RPST easily and rapidly tailorable for diverse applications. Specific RPST functions include: (1) definition of analysis objectives and performance metrics; (2) selection of process templates from a process-template library; (3) configuration of process models for detailed simulation and schedule analysis; (4) design of operations-analysis experiments; (5) schedule and simulation-based process analysis; and (6) optimization of performance by use of genetic algorithms and simulated annealing. The main benefits afforded by RPST are provision of information that can be used to reduce costs of operation and maintenance, and the capability for affordable, accurate, and reliable prediction and exploration of the consequences of many alternative proposed decisions.

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*In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:*

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## Simulator of Space Communication Networks

Multimission Advanced Communications Hybrid Environment for Test and Evaluation (MACHETE) is a suite of software tools that simulates the behaviors of communication networks to be used in space exploration, and predict the performance of established and emerging space communication protocols and services. MACHETE consists of four general software systems: (1) a system for kinematic modeling of planetary and spacecraft motions; (2) a system for characterizing the engineering impact on the

bandwidth and reliability of deep-space and *in-situ* communication links; (3) a system for generating traffic loads and modeling of protocol behaviors and state machines; and (4) a system of user-interface for performance metric visualizations. The kinematic-modeling system makes it possible to characterize space link connectivity effects, including occultations and signal losses arising from dynamic slant-range changes and antenna radiation patterns. The link-engineering system also accounts for antenna radiation patterns and other phenomena, including modulations, data rates, coding, noise, and multipath fading. The protocol system utilizes information from the kinematic-modeling and link-engineering systems to simulate operational scenarios of space missions and evaluate overall network performance. In addition, a Communications Effect Server (CES) interface for MACHETE has been developed to facilitate hybrid simulation of space communication networks with actual flight/ground software/hardware embedded in the overall system.

*This work was done by Loren Clare, Esther Jennings, Jay Gao, John Segui, and Winston Kwong of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1).*

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## Computing Q-D Relationships for Storage of Rocket Fuels

The Quantity Distance Measurement Tool is a GIS BASEP computer program that aids safety engineers by calculating quantity-distance (Q-D) relationships for vessels that contain explosive chemicals used in testing rocket engines. (Q-D relationships are standard relationships between specified quantities of specified explosive materials and minimum distances by which they must be separated from persons, objects, and other explosives to obtain specified types and degrees of protection.) The program uses customized geographic-information-system (GIS) software and calculates Q-D relationships in accordance with NASA's Safety Standard For Explosives, Propel-